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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/US92/10218 (22) International Filing Date: 2 December 1992 (02.12.92) (30) Priority data: 802,392 4 December 1991 (04.12.91) US (71) Applicant: E.I. DU PONT DE NEMOURS AND COMPANY [US/US]; 1007 Market Street, Wilmington, DE 19898 (US). (72) Inventor: SIKORA, Robert, John ; 18494 Jamestown Circle, Northville, MI 48167 (US). (74) Agents: FRICKE, Hilmar, L. et al.; E.I. du Pont de Nemours and Company, Legal/Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US).		(81) Designated States: CA, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>
(54) Title: CATHODIC ELECTRODEPOSITION COATINGS CONTAINING A FLOW CONTROL AGENT (57) Abstract <p>An improved aqueous cathodic electrocoating composition that contains a film forming binder comprising an epoxy-amine adduct and a blocked polyisocyanat crosslinking agent and a flow control agent of an aliphatic dibasic acid ester; finishes formed from the composition have improved film smoothness.</p>		

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TITLE
CATHODIC ELECTRODEPOSITION COATINGS
CONTAINING A FLOW CONTROL AGENT

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BACKGROUND OF THE INVENTION

This invention is directed to a cathodic electrocoating composition and in particular to a cathodic electrocoating composition containing a flow control agent which improves the smoothness of an electrodeposited film of the composition.

10 The coating of electrically conductive substrates by an electrodeposition process (also called an electrocoating process) is a well known and important industrial process. Electrodeposition of primers to automotive substrates is widely used in the automotive industry. In this process, a conductive article, such as an autobody or an auto part, is immersed in a bath of a coating composition of an aqueous emulsion of film forming polymer and acts as an electrode in the electrodeposition process. An electric current is passed between the article and a counter-electrode in electrical contact with the aqueous emulsion, until a desired coating is deposited on the article. In a cathodic electrocoating process, 25 the article to be coated is the cathode and the counter-electrode is the anode.

Resin compositions used in the bath of a typical cathodic electrodeposition process also are well known in the art. These resins typically are made from polyepoxide resins which have been chain extended and then an adduct is formed to include amine groups in the resin. Amine groups typically are introduced through reaction of the resin with an amine compound. These resins are blended with a crosslinking agent and then neutralized with an acid to form a 35

water emulsion which is usually referred to as a principal emulsion.

The principal emulsion is combined with a pigment paste, coalescent solvents, water, and other additives to form the electrocoating bath. The electrocoating bath is placed in an insulated tank containing the anode. The article to be coated is the cathode and is passed through the tank containing the electrodeposition bath. The thickness of the coating that is deposited on the article being electrocoated is a function of the bath characteristics, the electrical operating characteristics, the immersion time, and the like.

The resulting coated article is removed from the bath after a set period of time and is rinsed with deionized water. The coating on the article is cured typically in an oven at sufficient temperature to produce a crosslinked finish on the article.

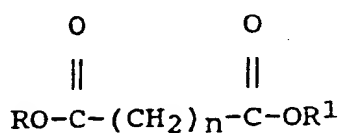
Cathodic electrocoating compositions and resin compositions, coating baths, and cathodic electrodeposition processes are disclosed in Jerabek et al U.S. Patent 3,922,253 issued November 25, 1975; Wismer et al US 4,419,467 issued December 6, 1983; Belanger US 4,137,140 issued January 30, 1979 and Wismer et al US 4,468,307 issued August 25, 1984.

A continuing problem with cathodic electrocoating compositions has been to formulate a composition that forms a smooth finish when electrodeposited and subsequently cured. Various additives have been used but tend to adversely affect the cure of the resulting finish. The flow control agent that is used in the cathodic electrocoating composition of this invention allows for the

deposition of a smooth finish and does not adversely affect curing of the finish.

SUMMARY OF THE INVENTION

5 An improved aqueous electrocoating composition having a binder of an epoxy-amine adduct and a blocked polyisocyanate crosslinking agent; wherein the improvement is the use of a flow control agent of an aliphatic dibasic acid ester of the
10 following formula:



15 wherein R and R¹ are saturated aliphatic hydrocarbon groups and n = 2-7.

DETAILED DESCRIPTION OF THE INVENTION

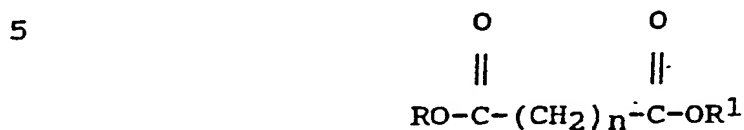
 The flow control agent is readily incorporated into the electrocoating composition since
20 it is compatible with the other constituents of the composition. The flow control agent remains stable in the composition and in the electrocoating bath for extended periods of time under conventional bath operating conditions since it is not reactive with the
25 other constituents in the composition. The flow control agent aids in flow of electrodeposited coatings to form smooth finishes.

 The flow control agent is used in the electrocoating composition at a level of least 0.5 by weight, based on the total weight of binder solids in
30 the electrocoating composition and preferably, it is used at a level of about 0.5-10% by weight. More preferably, about 1-3% by weight of the flow control agent is used. The binder of the electrocoating

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composition is the epoxy amine adduct and the blocked polyisocyanate crosslinking agent.

The flow control agent has the following formula:



wherein R and R¹ are saturated aliphatic hydrocarbon groups preferably, methyl or ethyl group, and n = 2-7.

10 Preferably, R and R¹ are methyl groups, and n = 3-4. Also, the flow control agent can be a mixture of the aliphatic dibasic acid esters.

Typically useful flow control agents are dimethylmalonate, diethylmalonate, dimethyl succinate, 15 diethyl succinate, dimethyl glutarate, diethyl glutarate, dimethyl adipate, diethyl adipate, dimethyl pimelate, diethyl primelate, dimethyl suberate, diethyld suberate, dimethyl azelate, diethyl azelate and mixtures of any of the above.

20 One particularly preferred flow control agent is a mixture of dimethyl adipate and dimethyl glutarate which is sold as "Dibasic Ester - 3" by Du Pont.

The flow control agent can be added to the 25 electrocoating composition at almost anytime. It can be added to the principal emulsion, to the bath or to the pigment paste used to form the electrocoating composition.

Most principal emulsions used in an 30 electrocoating composition comprise an aqueous emulsion of a binder of an epoxy amine adduct blended with a cross-linking agent which has been neutralized with an acid to form a water soluble product.

The flow control agent is potentially usable 35 with a variety of different cathodic electrocoat

resins, but the preferred resin is the typical epoxy-amine adduct of the prior art. These resins are generally disclosed in U.S. Patent No. 4,419,467 which is incorporated herein by reference.

5 Preferred crosslinkers for the above resins are also well known in the prior art. These are aliphatic, cycloaliphatic and aromatic isocyanates such as hexamethylene diisocyanate, cyclohexamethylene diisocyanate, toluene diisocyanate, methylene diphenyl
10 diisocyanate and the like. These isocyanates are pre-reacted with a blocking agent such as oximes, alcohols, and caprolactams which block the isocyanate functionality i.e. the crosslinking functionality. Upon heating the blocking agents separate, thereby
15 providing a reactive isocyanate group and crosslinking occurs. Isocyanate crosslinkers and blocking agents are well known in the prior art and also are disclosed in the aforementioned U.S. Patent No. 4,419,467.

The cathodic binder of the epoxy amine
20 adduct and the blocked isocyanate are the principal resinous ingredients in the electrocoating composition and are usually present in amounts of about 30 to 50 percent by weight of solids. To form an electrocoating bath, the solids are generally reduced
25 with an aqueous medium.

Besides the binder resin described above, the electrocoating composition usually contains pigment which is incorporated into the composition in the form of a pigment paste. The pigment paste is
30 prepared by grinding or dispersing a pigment into a grinding vehicle and optional ingredients such as wetting agents, surfactants, and defoamers. Any of the pigment grinding vehicles that are well known in the art can be used. After grinding, the particle
35 size of the pigment should be as small as practical,

generally, the particle size is about 6-8 using a Hegman grinding gauge.

Pigments which can be used in this invention include titanium dioxide, basic lead silicate, strontium chromate, carbon black, iron oxide, clay and the like. Pigments with high surface areas and oil absorbencies should be used judiciously because these can have an undesirable affect on coalescence and flow of the electrodeposited coating.

The pigment to binder weight ratio is also important and should be preferably less than 0.5:1, more preferably less than 0.4:1, and usually about 0.2 to 0.4:1. Higher pigment to binder weight ratios have been found to adversely affect coalescence and flow.

The coating compositions of the invention can contain optional ingredients such as wetting agents, surfactants, wetting agents, defoamers and the like. Examples of surfactants and wetting agents include alkyl imidazolines such as those available from Ciba-Geigy Industrial Chemicals as "Amine C", acetylenic alcohols available from Air Products and Chemicals as "Surfynol 104". These optional ingredients, when present, constitute from about 0.1 to 20 percent by weight of binder solids of the composition.

Optionally, plasticizers can be used to promote flow. Examples of useful plasticizers are high boiling water immiscible materials such as ethylene or propylene oxide adducts of nonyl phenols or bisphenol A. Plasticers are usually used at levels of about 0.1 to 15 percent by weight resin solids.

The electrocoating composition of this invention is an aqueous dispersion. The term "dispersion" as used within the context of this

invention is believed to be a two-phase translucent or opaque aqueous resinous binder system in which the binder is in the dispersed phase and water the continuous phase. The average particle size diameter of the binder phase is about 0.1 to 10 microns, preferably, less than 5 microns. The concentration of the binder in the aqueous medium in general is not critical, but ordinarily the major portion of the aqueous dispersion is water. The aqueous dispersion usually contains from about 3 to 50 percent preferably 5 to 40 percent by weight binder solids. Aqueous binder concentrates which are to be further diluted with water when added to an electrocoating bath, generally have a range of binder solids of 10 to 30 percent weight.

The following example illustrates the invention. All parts and percentages are on a weight basis unless otherwise indicated.

EXAMPLE

Preparation of Chain Extended Polyepoxide

The following ingredients were charged into a suitable reaction vessel: 1478 parts Epon 828® (epoxy resin of diglycidyl ether of Bisphenol A from Shell Chemical Company having an epoxy equivalent weight of 188); 533 parts ethoxylated Bisphenol A having a hydroxy equivalent weight of 247 (Synfac 8009® from Milliken Company); 427 parts of Bisphenol A; and 121 parts xylene. The resulting reaction mixture was heated to 160°C under a nitrogen blanket and held at this temperature for 1 hour. 5.1 parts dimethyl benzyl amine were added and the mixture was held at 147°C until a 1150 epoxy equivalent weight was obtained. The reaction mixture was cooled to 98°C and 168 parts of diketimine (reaction product of

diethylenetriamine and methyl isobutyl ketone at 72.7% solids) and 143 parts of methyl ethanol amine were added. The resulting mixture was held at 120°C for 1 hour and then 727 parts of methyl isobutyl ketone were added. The resulting resin solution had a non-volatile content of 75%.

Preparation of Flex Emulsion Additive

A flex emulsion additive was prepared by charging 2322 parts of Jeffamine D-2000® (polyoxypropylene-diamine having a molecular weight of 1992 from Texaco Company) to a reaction vessel under a nitrogen atmosphere and heated to 90°C. A solution of 859 parts of Epon 1001® (polyglycidyl ether of Bisphenol A having an epoxy equivalent weight of 500 from Shell Chemical Company) in 345 parts of 2-butoxyethanol was added. An aqueous dispersion was formed by adding 68 parts of acetic acid and 5345 parts of deionized water.

Preparation of Quaternizing Agent

	<u>Parts by</u> <u>Weight</u>	<u>NV*</u>
Blocked Isocyanate Solution		
25 (2-Ethylhexanol half capped toluene diisocyanate in methyl isobutyl ketone)	320.0	304.0
Dimethylethanol amine	87.2	87.2
Aqueous lactic acid solution	117.6	88.2
30 2-Butoxyethanol	<u>39.2</u>	<u> </u>
Total	564.0	479.4

* Non-Volatiles

The quaternizing agent was prepared by adding dimethylethanol amine to the blocked isocyanate solution in a suitable reaction vessel at ambient

temperature. An exothermic reaction occurred and the reaction mixture was stirred for one hour and held at a temperature of 80°C. Lactic acid solution was added followed by the addition of 2-butoxyethanol. The reaction mixture was stirred for an additional hour at 65°C to form the quaternizing agent.

Preparation of Pigment Grinding Vehicle

		<u>Parts by</u>	<u>NV*</u>
		<u>Weight</u>	
10	Epon 829® (epoxy resin of diglycidyl ether of Bisphenol A from Shell Chemical Company having an epoxy equivalent weight of 192-203)	710.0	682.0
15	Bisphenol A	289.6	289.6
	Blocked isocyanate solution (described above)	406.0	386.1
	Quaternizing Agent (prepared above)	496.3	421.9
	Deionized water	71.2	
20	2-Butoxyethanol	<u>1095.2</u>	<u> </u>
	Total	3068.3	1779.6

Epon 829® and Bisphenol A were charged under a nitrogen atmosphere to a suitable reaction vessel and heated to 150-160°C to initiate an exothermic reaction. The reaction mixture was cooled to 120°C and the blocked isocyanate solution was added. The temperature of the reaction mixture was held at 110-120°C for one hour, followed by the addition of 2-butoxyethanol. The reaction mixture then was cooled to 85-90°C, homogenized and then the deionized water was added followed by the addition of the Quaternizing agent. The resulting mixture had a solids content of about 58%.

Preparation of Emulsion

		<u>Parts by</u> <u>Weight</u>	<u>NV</u>
5	Chain Extended Polyepoxide (prepared above)	3210	2440
	Crosslinking Resin Solution ¹	2229	1560
	Downol PPH [®] (from Dow Chemical Co.)	40	
	Surfactant ²	60	
	Deionized water	5392	
10	Lactic acid	137	
	Flex emulsion additive (prepared above)	<u>964</u>	<u>347</u>
	Total	12032	4347

1 Crosslinking resin solution is formed from
 15 half-capping toluene diisocyanate (80/20 2,4/2,6 isomer mixture) with 2-hexyloxy ethanol and reacting the resulting product with trimethylol propane in a 3:1 molar ratio in methyl isobutyl ketone to form a 70% solids solution.

20 2 Surfactant is a mixture of 120 parts Amine C from Ciba-Geigy, 120 parts acetylenic alcohol, commercially available as Surfynol 104[®], 120 parts of 2-butoxy ethanol and 221 parts by weight of deionized water and 19 parts glacial acetic acid.

25 The chain extended polyepoxide is thoroughly mixed with the crosslinking resin solution, Downol PPH[®], lactic acid and the surfactant. Deionized water was added under agitation to form a dispersion and then the flex emulsion additive was blended into
 30 the resulting composition. The resulting dispersion has a solids content of 36% and a pH of 6.8. Solvent was removed from the dispersions and the solids content was adjusted to 36%.

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Preparation of Pigment Paste

		<u>Parts by</u> <u>Weight</u>	<u>NV</u>
	Pigment Grinding Vehicle	266.20	154.64
5	(prepared above)		
	Deionized water	455.30	
	Carbon black pigment	25.98	24.26
	Aluminum silicate pigment	51.85	54.96
	Lead silicate pigment	22.24	24.26
10	Dibutyl tin oxide	16.34	17.00
	Titanium dioxide pigment	<u>296.23</u>	<u>292.15</u>
	Total	1134.14	567.28

The above constituents were charged into a
 15 conventional sand mill and ground to a No. 7 Hegman
 fineness.

Preparation of an Electrocoating Baths A-D

		<u>Parts by Weight</u>			
	<u>Bath</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
20	Emulsion	1517	1517	1517	1517
	(prepared above)				
	Pigment Paste	508	508	508	508
	(prepared above)				
	Deionized water	1975	1972	1969	1966
	Flow Control Agent	<u>0</u>	<u>3</u>	<u>6</u>	<u>9</u>
25	(Dibasic Ester - 3 previously described herein)				
	Total	4000	4000	4000	4000

Electrocoating baths A-D were prepared by
 blending the above ingredients together. A separate
 zinc phosphate coated cold-rolled steel panel was
 30 cathodically electrocoated in each bath at 225 volts
 for 2 minutes at a bath temperature of 28°C and was
 baked at 182°C for 17 minutes.

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The smoothness of each panel was measured with a profilometer. The results are as follows.

	Electrocoating Bath	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
5	Profile (Microns)	0.432	0.406	0.356	0.279

The results show that Baths B, C and D which contained increasing amounts of flow control agent had a smoother finish than Bath A which did not contain the flow control agent. Other properties such as chip resistance and solvent resistance were not adversely affected by the flow control agent.

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CLAIMS

1. In a cathodic electrocoating composition, comprising an aqueous carrier having dispersed therein a film forming binder comprising an epoxy-amine adduct and a blocked polyisocyanate crosslinking agent; wherein the improvement consists essentially of a flow control agent of the formula



wherein R and R¹ are aliphatic hydrocarbon groups, and n = 2 to 7.

- 15 2. The cathodic electrocoating composition of claim 1 wherein R and R¹ are individually selected from methyl or ethyl groups.

- 20 3. The cathodic electrocoating composition of claim 1 wherein the flow control agent is present in an amount of about 0.5-10% by weight, based on the weight of the film forming binder of the composition.

- 25 4. The cathodic electrocoating composition of claim 3 wherein R and R¹ are methyl groups and n = 3-4.

- 30 5. The cathodic electrocoating composition of claim 3 wherein the flow control agent consists of a mixture of dimethyl adipate and dimethyl glutarate.

6. In a method of preparing a cathodic electrocoating composition comprising the following steps in any workable order:

- 35 (a) preparing an epoxy-amine adduct;

- (b) preparing a blocked polyisocyanate crosslinking agent;
- (c) blending the epoxy amine adduct with the blocked polyisocyanate crosslinking agent;
- 5 (d) neutralizing the epoxy-amine adduct with an organic acid to form an emulsion;
- (e) blending the emulsion with a pigment paste; and
- (e) adding a flow control agent to the electrocoating composition to improve flow of the coating on electrodeposition and curing of the coating; wherein the flow control agent consists essentially of a composition of the formula
- 10



wherein R and R¹ are aliphatic hydrocarbon groups, and n = 2-7.

20 7. The method of claim 6 wherein R and R¹ are individually selected from the groups of methyl or ethyl groups.

25 8. The method of claim 6 wherein the flow control agent is present in an amount of about 0.5-10% by weight, based on the weight of the film forming constituents of the composition.

30 9. The method of claim 8 wherein R and R¹ are methyl groups and n = 3-4 of the flow control agent.

35 10. The method of claim 9 wherein the flow control agent consist of a mixture of dimethyl adipate and dimethyl glutarate.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 92/10218

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁴		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁵ : C 25 D 13/10, C 25 D 13/06, C 09 D 5/44, C 09 D 7/06		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁵	C 25 D 13/00, C 09 D 5/00, C 09 D 7/00	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 4 883 572 (RAO et al.) 28 November 1989 (28.11.89), claims; examples. --	1, 6
Y	GB, A, 1 033 466 (THE DISTILLERS COMPANY LIMITED) 22 June 1966 (22.06.66), claims; examples. --	1-4
Y	EP, A1, 0 026 982 (ROHM AND HAAS COMPANY) 15 April 1981 (15.04.81), claims; examples. --	1-3
Y	DE, A1, 2 441 624 (FORD-WERKE AG) 27 March 1975 (27.03.75), claims; pages 10-11. ----	1-2
<p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"Z" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
28 February 1993	18.03.93	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	PAMMINGER e.h.	

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ANHANG

zum internationalen Recherchen-
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ANNEX

to the International Search
Report to the International Patent
Application No.

ANNEXE

au rapport de recherche inter-
national relatif à la demande de brevet
international n°

PCT/US 92/10218 SAE 67928

In diesem Anhang sind die Mitglieder
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			US A	4946569	07-08-90

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			JP A2	56050976	08-05-81
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DE A1	2441624	27-03-75	BE A1	819621	31-12-74
			CA A1	1045277	26-12-78
			DE C2	2441624	21-10-82
			GB A	1438429	09-06-76
			JP A2	50051537	08-05-75
			US A	3991133	09-11-76

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(21) International Application Number: PCT/US92/10218 (22) International Filing Date: 2 December 1992 (02.12.92) (30) Priority data: 802,392 4 December 1991 (04.12.91) US (71) Applicant: E.I. DU PONT DE NEMOURS AND COMPANY [US/US]; 1007 Market Street, Wilmington, DE 19898 (US). (72) Inventor: SIKORA, Robert, John ; 18494 Jamestown Circle, Northville, MI 48167 (US). (74) Agents: FRICKE, Hilmar, L. et al.; E.I. du Pont de Nemours and Company, Legal/Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US).		(81) Designated States: CA, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>With amended claims.</i> Date of publication of the amended claims: 24 June 1993 (24.06.93)
(54) Title: CATHODIC ELECTRODEPOSITION COATINGS CONTAINING A FLOW CONTROL AGENT (57) Abstract An improved aqueous cathodic electrocoating composition that contains a film forming binder comprising an epoxy-amine adduct and a blocked polyisocyanat crosslinking agent and a flow control agent of an aliphatic dibasic acid ester; finishes formed from the composition have improved film smoothness.		

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CS	Czechoslovakia	LU	Luxembourg	SU	Soviet Union
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AMENDED CLAIMS

[received by the International Bureau on 18 May 1993 (18.05.93);
original claims 1 and 6 amended; remaining claims unchanged (2 pages)]

1. A cathodic electrocoating composition,
comprising an aqueous carrier having dispersed therein
a film forming binder comprising an epoxy-amine adduct
and a blocked polyisocyanate crosslinking agent;
characterized in that the composition contains a flow
control agent of the formula



wherein R and R¹ are aliphatic hydrocarbon groups, and
n = 2-7.

2. The cathodic electrocoating composition
of claim 1 wherein R and R¹ are individually selected
from methyl or ethyl groups.

3. The cathodic electrocoating composition
of claim 1 wherein the flow control agent is present
in an amount of about 0.5-10% by weight, based on the
weight of the film forming binder of the composition.

4. The cathodic electrocoating composition
of claim 3 wherein R and R¹ are methyl groups and n =
3-4.

5. The cathodic electrocoating composition
of claim 3 wherein the flow control agent consists of
a mixture of dimethyl adipate and dimethyl glutarate.

6. In a method of preparing a cathodic
electrocoating composition comprising the following
steps in any workable order:

- (a) preparing an epoxy-amine adduct;

- 5 (b) preparing a blocked polyisocyanate crosslinking agent;
(c) blending the epoxy amine adduct with the blocked polyisocyanate crosslinking agent;
(d) neutralizing the epoxy-amine adduct with an organic acid to form an emulsion;
(e) blending the emulsion with a pigment paste; and characterized in that
10 (f) a flow control agent is added to the electrocoating composition to improve flow of the coating on electrodeposition and curing of the coating; wherein the flow control agent consists essentially of a composition of the formula



wherein R and R¹ are aliphatic hydrocarbon groups, and n = 2-7.

20 7. The method of claim 6 wherein R and R¹ are individually selected from the groups of methyl or ethyl groups.

25 8. The method of claim 6 wherein the flow control agent is present in an amount of about 0.5-10% by weight, based on the weight of the film forming constituents of the composition.

30 9. The method of claim 8 wherein R and R¹ are methyl groups and n = 3-4 of the flow control agent.

35 10. The method of claim 9 wherein the flow control agent consists of a mixture of dimethyl adipate and dimethyl glutarate.